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ENGINEERING DESIGN DATA FOR ALUMINUM ALLOY 7475 IN THE T761 AND T61 CONDITION

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RESEARCH INSTITUTE

TECHNICAL REPORT AFML-TR-72-173

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RUSSELL R. CERVAY

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FOREWORD

This report was prepared by the University of Dayton Research Institute (UDRI), Dayton, Ohio. The work was performed under USAF Contract No. F33615-71-C-1054. The contract was initiated under Project No. 7381, "Materials Applications," Task No. 738106, "Engineering and Design Data," and administered by the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio, Mr. David C. Watson, AFML/LAE, Project Engineer.

All (or many) of the items compared in this report were commercial items that were not developed or manufactured to meet Government specifications, to withstand the tests to which they were subjected, or to operate as applied during this study. Any failure to meet the objectives of this study is no reflection on any of the commercial items discussed herein or on any manufacturer.

The author would like to acknowledge that testing performed for this program was accomplished by Messrs. Cambron, Eblin, and Maxwell of the UDRI.

The report covers work conducted from April 1971 to February 1972. The contractor's report number if UDRI-TR-72-25.

The report was submitted by the author in April 1972.

This technical report has been reviewed and is approved.

A. Olevitch

A. OLEVITCH
Chief, Materials Engineering Branch
Materials Support Division

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13. ABSTRACT

Tensile, exfoliation, fatigue, and fatigue crack growth properties were determined for a new aluminum sheet alloy, 7475, in two heat treated conditions, T761 and T61. The tensile properties of the T61 sheet were superior to those for the T761 sheet. The fatigue crack growth properties were the same from heat treatment to heat treatment and were unaffected by crack orientation in the plate. Conventional notched and unnotched fatigue data showed in the 7475 alloy had superior fatigue resistance compared to presently-in-use aluminum alloys. The exfoliation properties of the T761 sheet were slightly superior to those of the T61 heat treatment.

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SECTION I

INTRODUCTION

This program was initiated to develop engineering design data for the new aluminum sheet alloy, 7475, in two different heat treatments: T61 and T761. The aluminum sheet alloy is represented by Alcoa (Aluminum Company of America) as being one of the promising new aerospace alloys. Initial testing indicates that the material's fracture toughness and resistance to fatigue crack propagation are superior to aluminum alloy 7075-T6. The material, with its higher strength than currently-in-use aluminum alloys, will afford a lighter structure and/or increased structural life.

SECTION II

PROGRAM OUTLINE AND PROCEDURES

Two sheets of the material, 0.090 inches thick, were provided by Alcoa for the program. The sheets were of different heat treatments: T61 and T761.

The material properties that were investigated in this program were: (a) tensile, (b) fatigue crack growth, (c) fatigue (notched and smooth), and (d) exfoliation.

Tensile testing was performed at -65° F, 200°F, and room temperature in both the longitudinal (L) and transverse (T) directions. The data was obtained using conventional tensile specimens and procedures (see Figure 1).

Room temperature fatigue crack growth testing was performed with the crack oriented in both the longitudinal and transverse directions. A compact tension specimen was used for the cyclic crack growth testing (see Figure 2). Because of the thinness of the sample, doublers were used to prevent the samples from buckling.

An S-N curve was generated for both notched and smooth specimens in the longitudinal and transverse orientation (see Figures 3 and 4). All of the fatigue testing was performed in a room temperature laboratory environment.

The exfoliation testing was accomplished with rectangular samples with the edges beveled at a 45 degree angle. The exposure was for 1200 hours in an environmental chamber maintained at 120° F and 100 percent relative humidity.

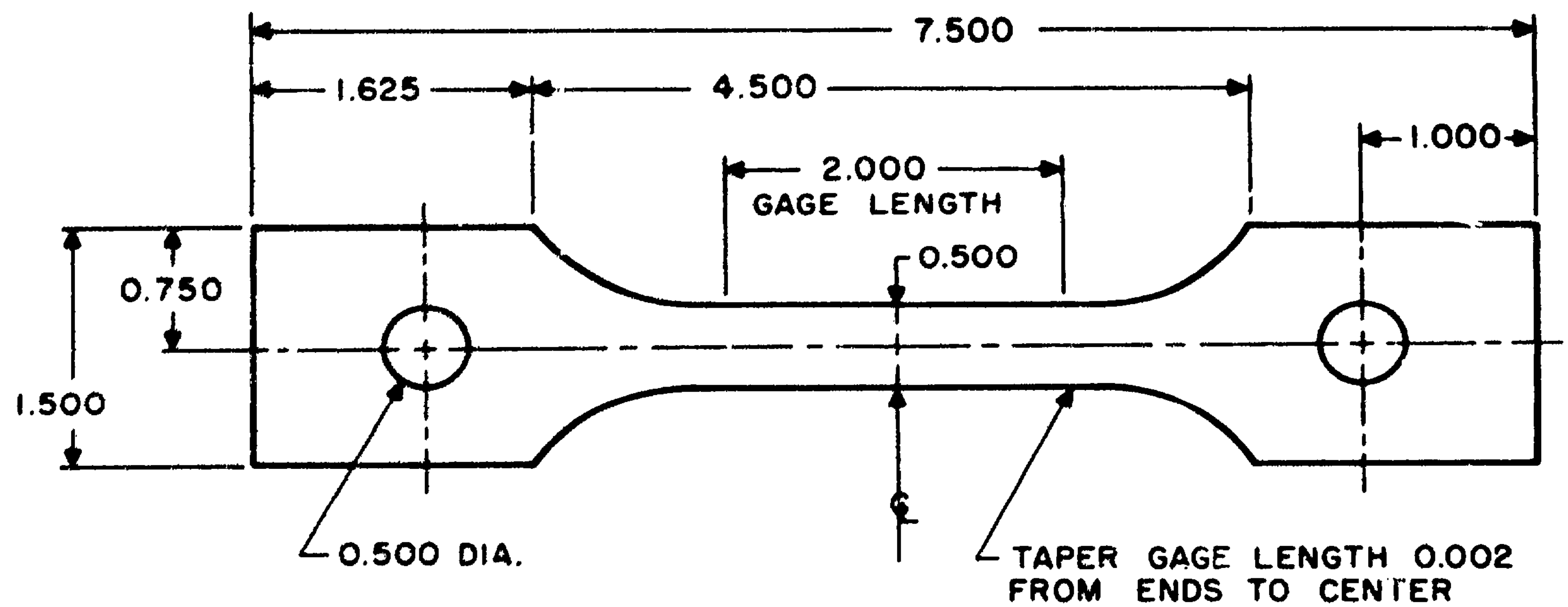

Figure 1. Tension Specimen

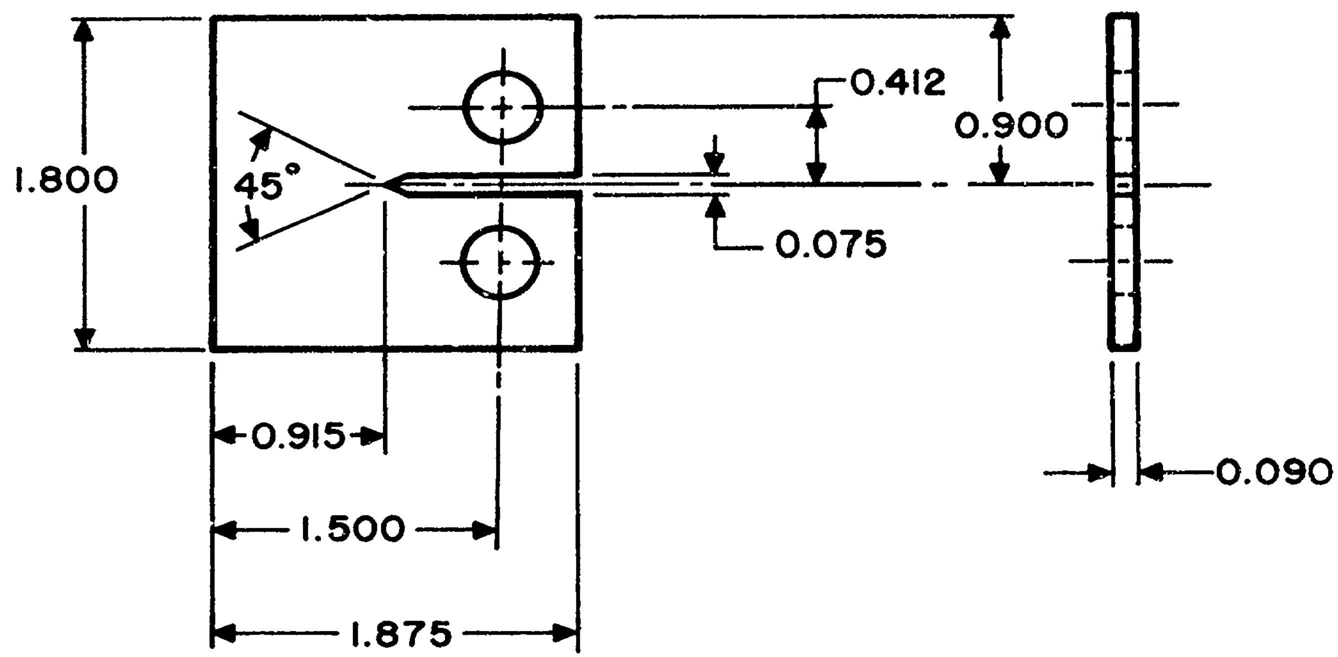

Figure 2. Compact Tension Crack Growth Specimen

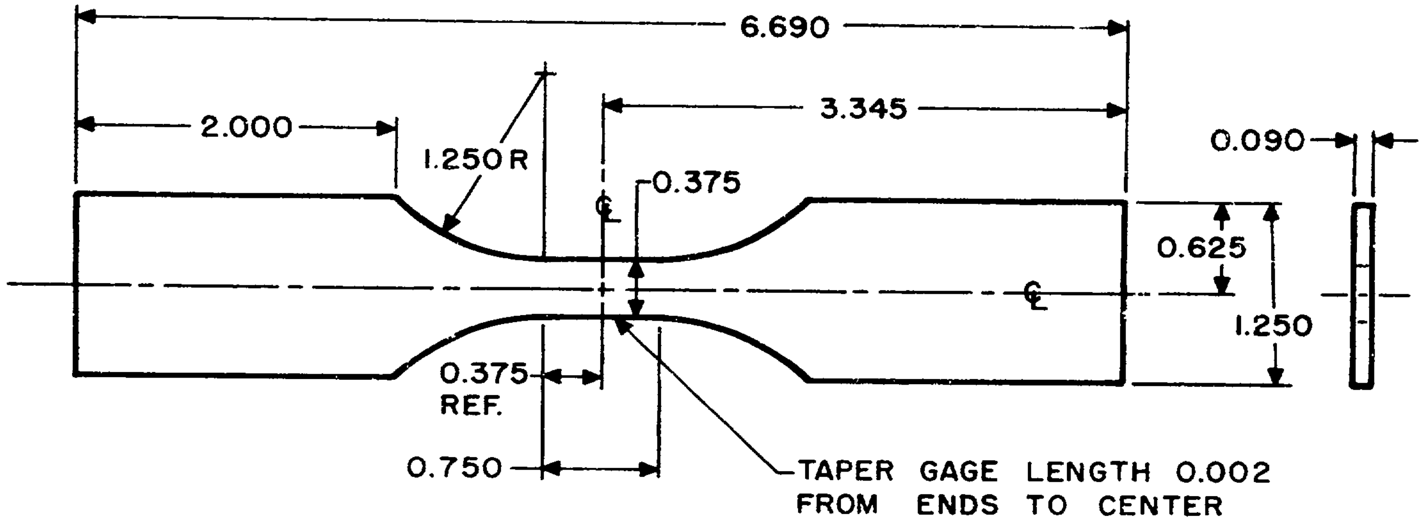

Figure 3. Smooth Fatigue Specimen

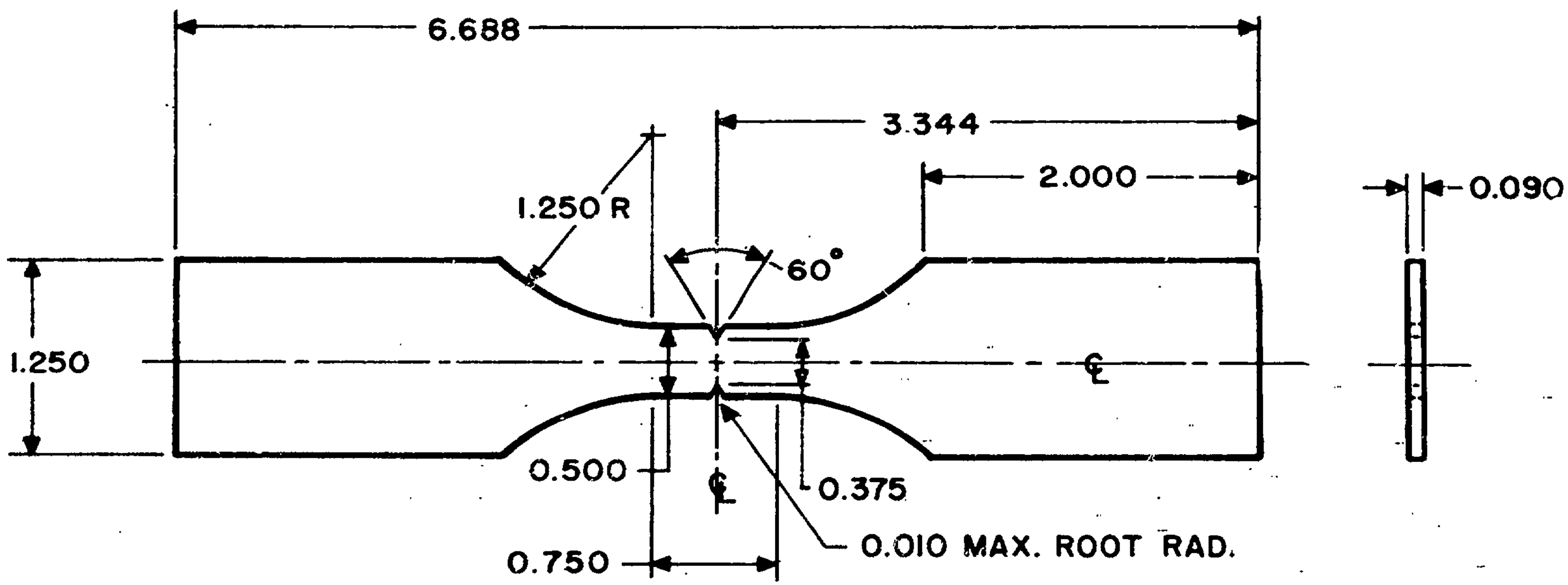

Figure 4. Notched Fatigue Specimen

SECTION III

RESULTS AND DISCUSSION

The results of the tensile tests are presented in Table I and Figures 5 through 7. The tensile properties are, in general, comparable to aluminum alloys 7075-T76, 7075-T651, and 2024-T851 (References 1-3). The T61 heat treatment had superior strength to the T761 heat treatment.

The cyclic crack growth test results are presented in Figure 8. There was no noticeable difference in crack growth rate with a change in specimen orientation. Any apparent difference caused by a change in heat treatment was fictitious, as all data was within a small scatter band.

The fatigue test results are presented in Figures 9 and 10. There is a great deal of scatter in the fatigue data for both the notched and smooth specimen configurations. The alloy appears to have superior fatigue properties when compared to aluminum alloys 7075 and 2024 (References 1-3). Due to the great scatter in the test data, there is no conclusive evidence that either of the two heat treatments is superior in fatigue.

On the rolled surfaces of the exfoliation samples, the degree of staining is approximately the same for the two heat treatments involved in the program (see Figure 11). However, the beveled edges of the T61 heat treated specimen are pitted (see Figure 12). The edges of the T761 sample were not affected by the environment to which they were exposed. In general, the aluminum alloy stood up very well to the corrosive environment.

TABLE I

Tensile Properties of 7475-T761 and T61 Aluminum Alloy Sheet
(0.090 inch thick)

Specimen	Heat Treatment	Temperature °F	Direction	Ultimate Strength ksi	Yield Strength ksi	Elongation in 2 in. G.L. %	Reduction of Area %
TR2	T761	-65	Longitudinal	76.5	65.8	12.3	29.2
TR5		-65		76.5	66.0	13.8	18.6
TR8		-65		76.3	66.0	12.3	29.8
TR1		R.T.		70.6	62.8	13.5	23.8
TR4		R.T.		70.0	61.8	13.2	28.0
TR7		R.T.		70.0	61.9	13.5	28.0
TR3		200		59.8	57.8	19.2	31.1
TR6		200		60.8	58.6	14.4	27.7
TR9		200		60.8	59.0	14.9	33.2
TT2	T761	-65	Transverse	77.4	65.7	12.0	30.5
TT5		-65		76.8	64.1	13.7	29.2
TT8		-65		76.2	63.9	13.6	30.1
TT1		R.T.		71.6	62.2	13.2	31.8
TT4		R.T.		70.9	61.4	13.8	20.5
TT7		R.T.		70.6	60.7	12.8	28.3
TT3		200		61.0	57.2	17.0	35.0
TT6		200		59.8	56.2	15.3	36.0
TT9		200		59.6	55.8	17.5	33.7
TR2	T61	-65	Longitudinal	83.5	78.4	13.4	31.4
TR5		-65		83.0	77.7	13.7	30.2
TR8		-65		82.7	77.7	11.9	28.3
TR1		R.T.		78.5	74.0	13.4	26.5
TR4		R.T.		78.6	73.9	14.1	29.7

TABLE I (Continued)

Specimen	Heat Treatment	Temperature °F	Direction	Ultimate Strength ksi	Yield Strength ksi	Elongation in 2 in. G.L. %	Reduction of Area %
TR7	T61	R.T.	Longitudinal	78.3	73.7	12.5	23.9
TR3		200		70.1	69.4	15.7	36.6
TR6		200		70.2	69.5	17.7	33.2
TR9		200		70.2	69.5	18.2	32.1
TT2	T61	-65	Transverse	84.1	78.3	12.8	23.9
TT5		-65		84.3	76.4	12.7	25.2
TT8		-65		84.2	76.5	11.8	23.9
TT1		R.T.		79.8	71.3	14.1	29.2
TT4		R.T.		78.7	74.4	13.5	30.3
TT7		R.T.		78.9	71.1	12.6	27.1
TT3		200		70.9	66.4	15.9	35.4
TT6		200		70.2	66.7	16.4	33.0
TT9		200		70.3	66.6	13.1	33.3

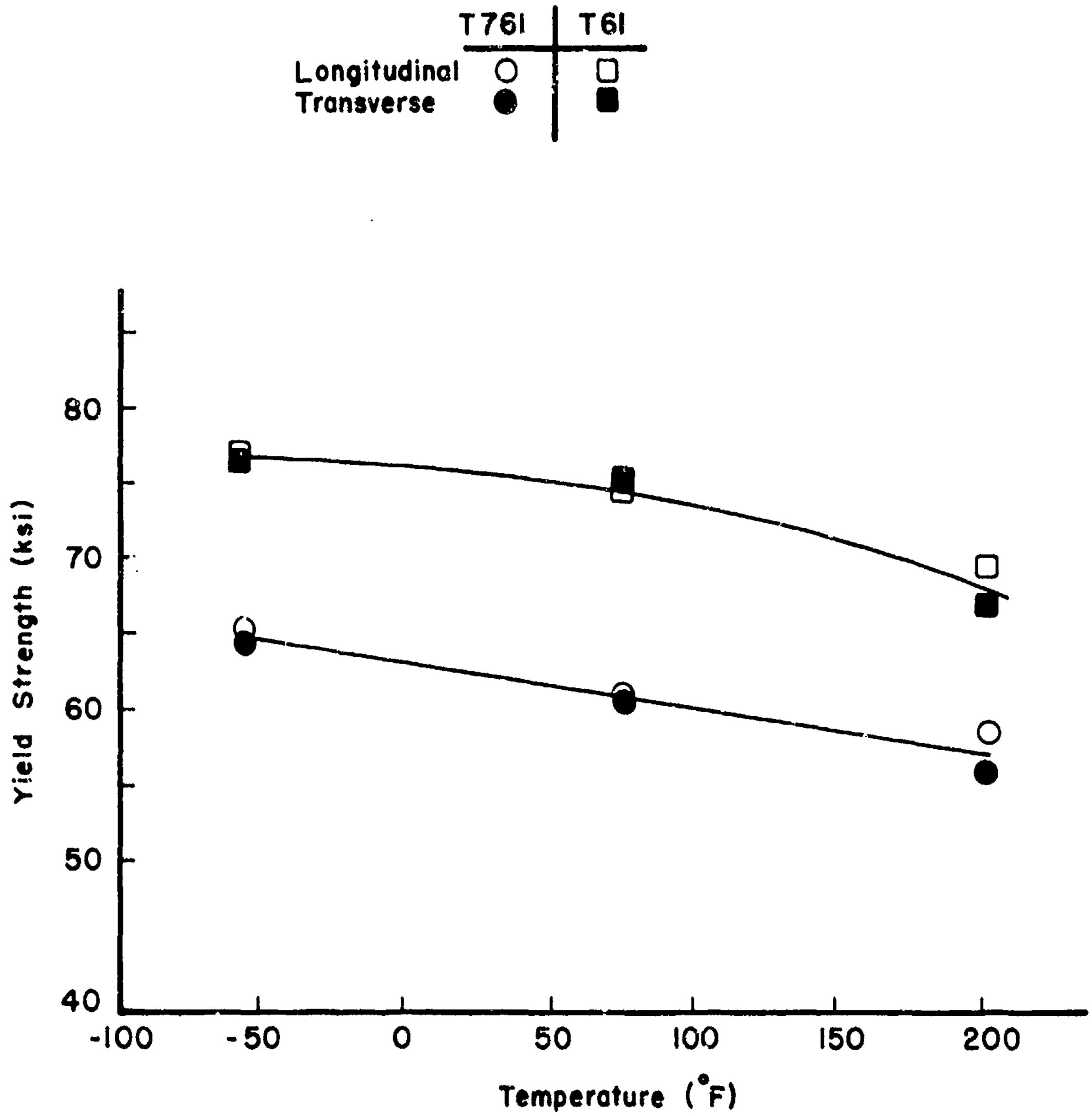

Figure 5. Yield Strength Versus Temperature for Aluminum Alloy 7475

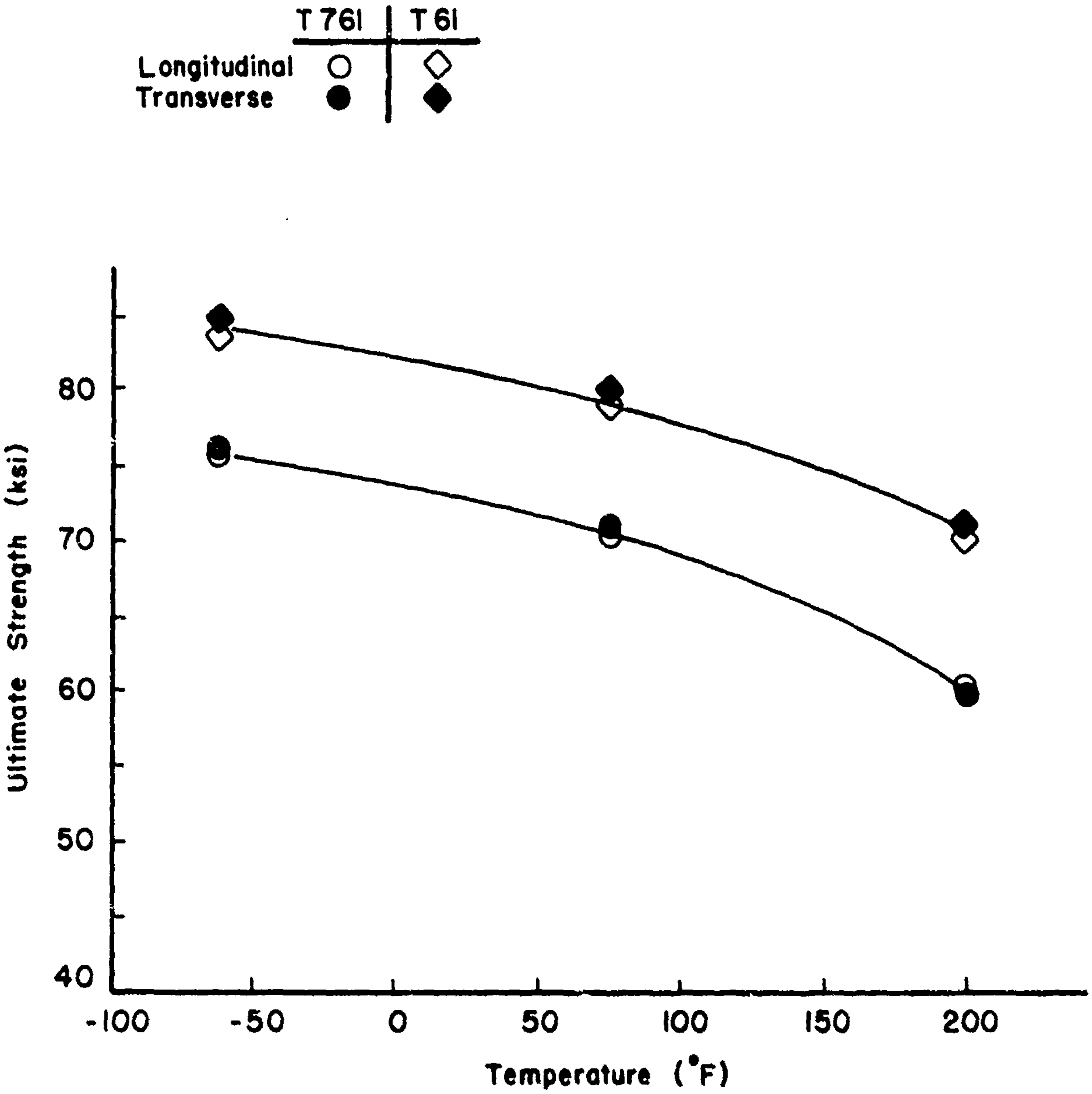

Figure 6. Ultimate Strength Versus Temperature for Aluminum Alloy 7475

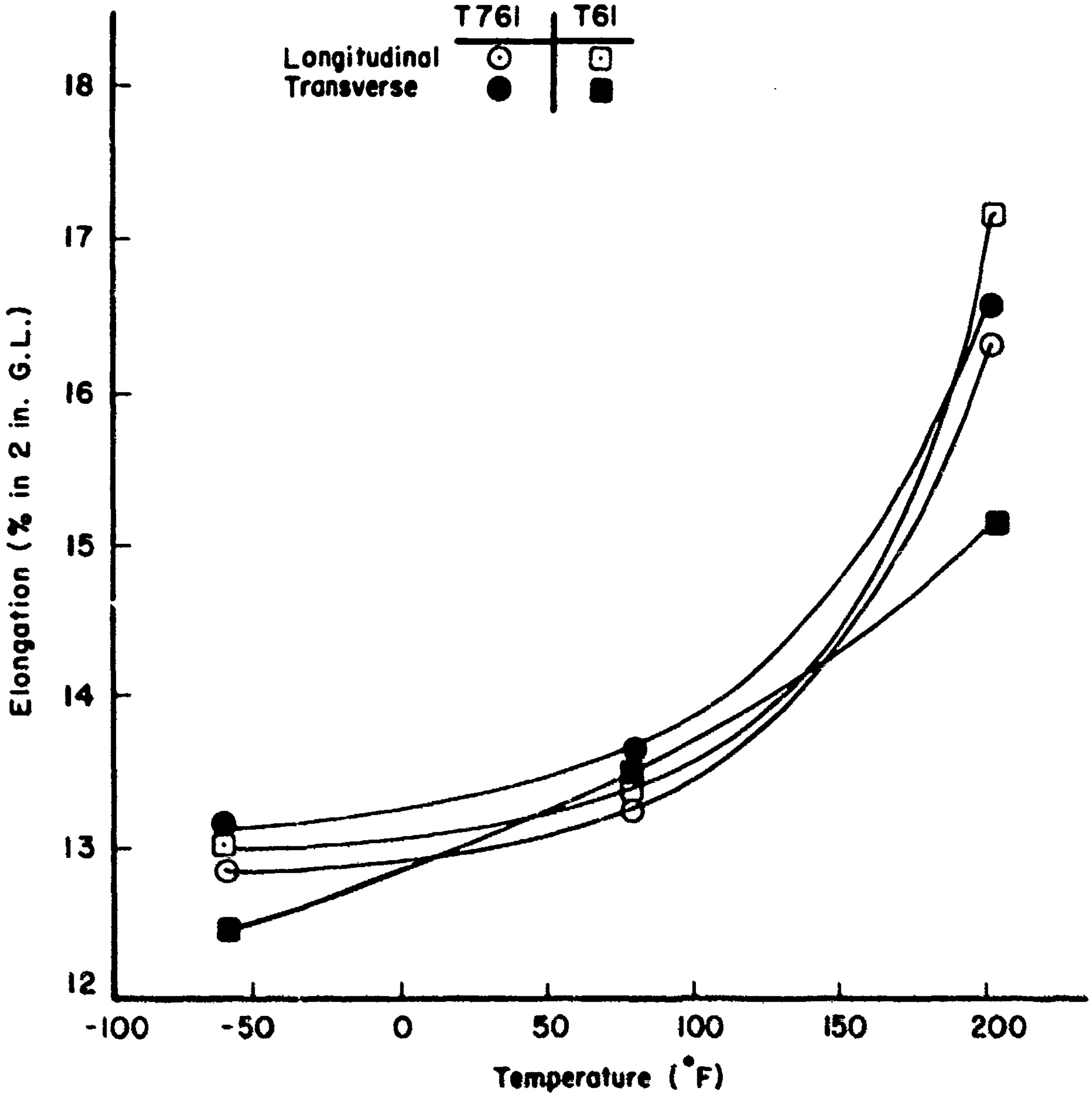

Figure 7. Elongation Versus Temperature for Aluminum Alloy 7475

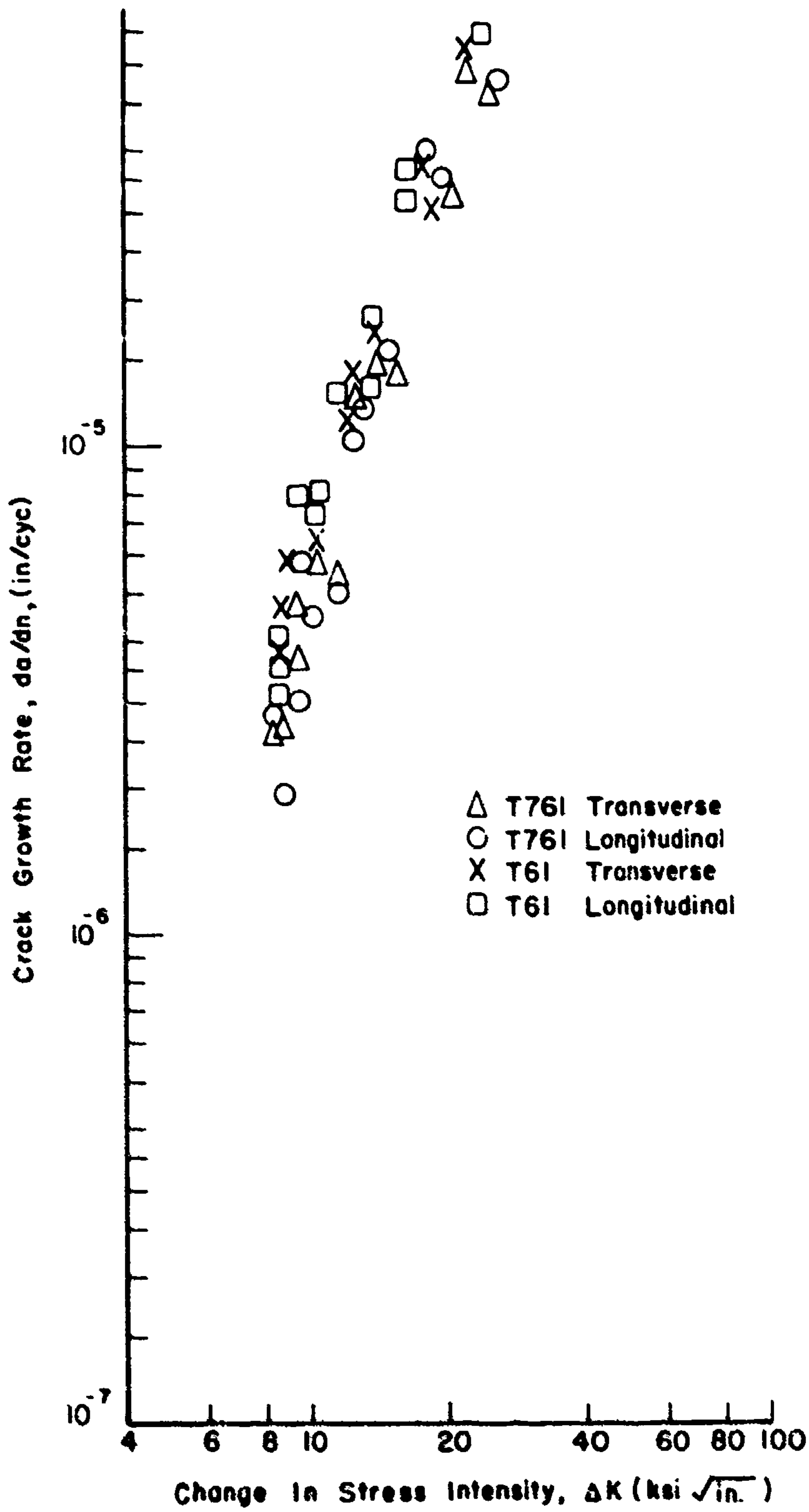

Figure 8. Crack Growth Rate Versus Stress Intensity Range for Aluminum Alloy 7475

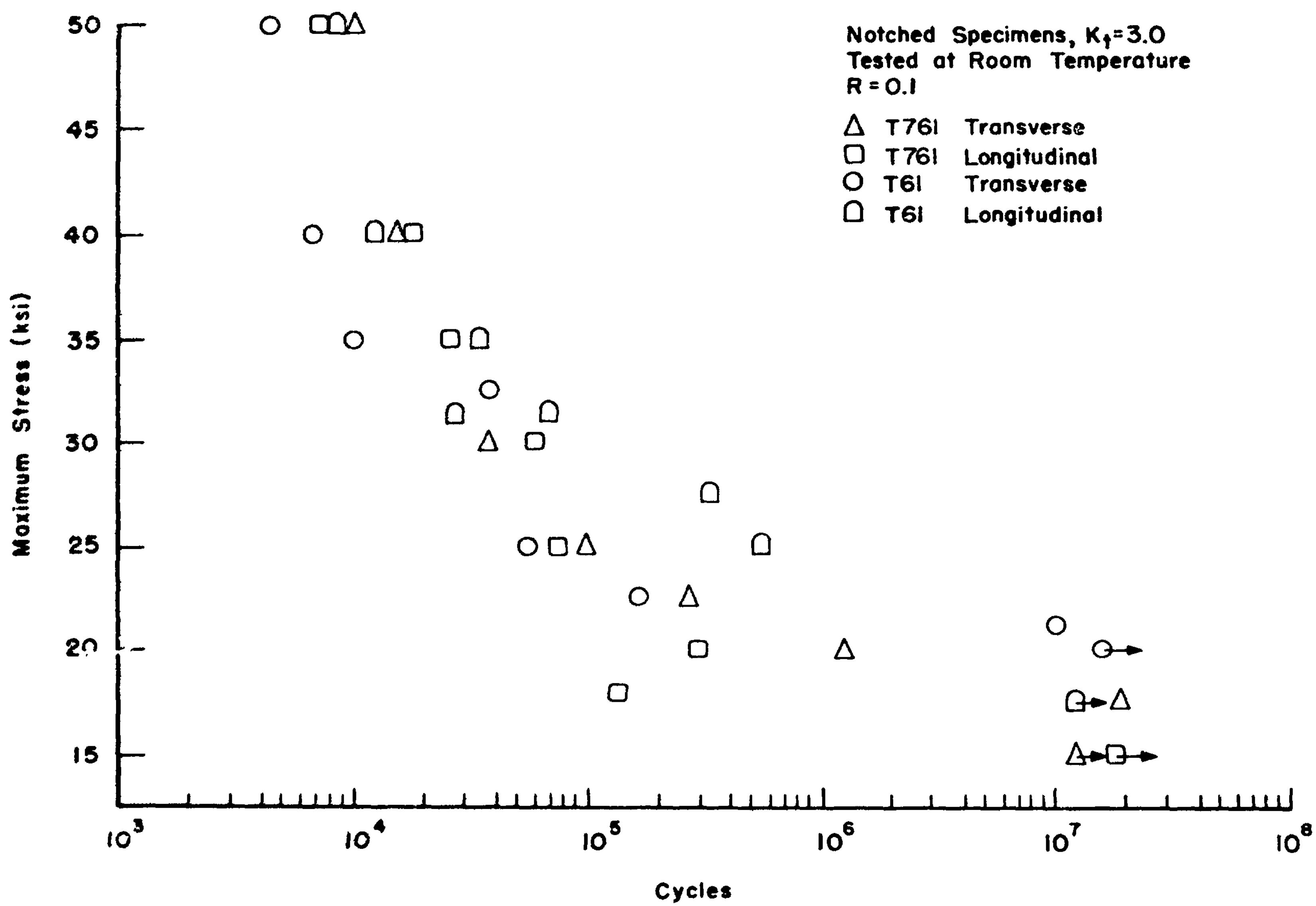

Figure 9. Notched Fatigue Test Results for Aluminum Alloy 7475

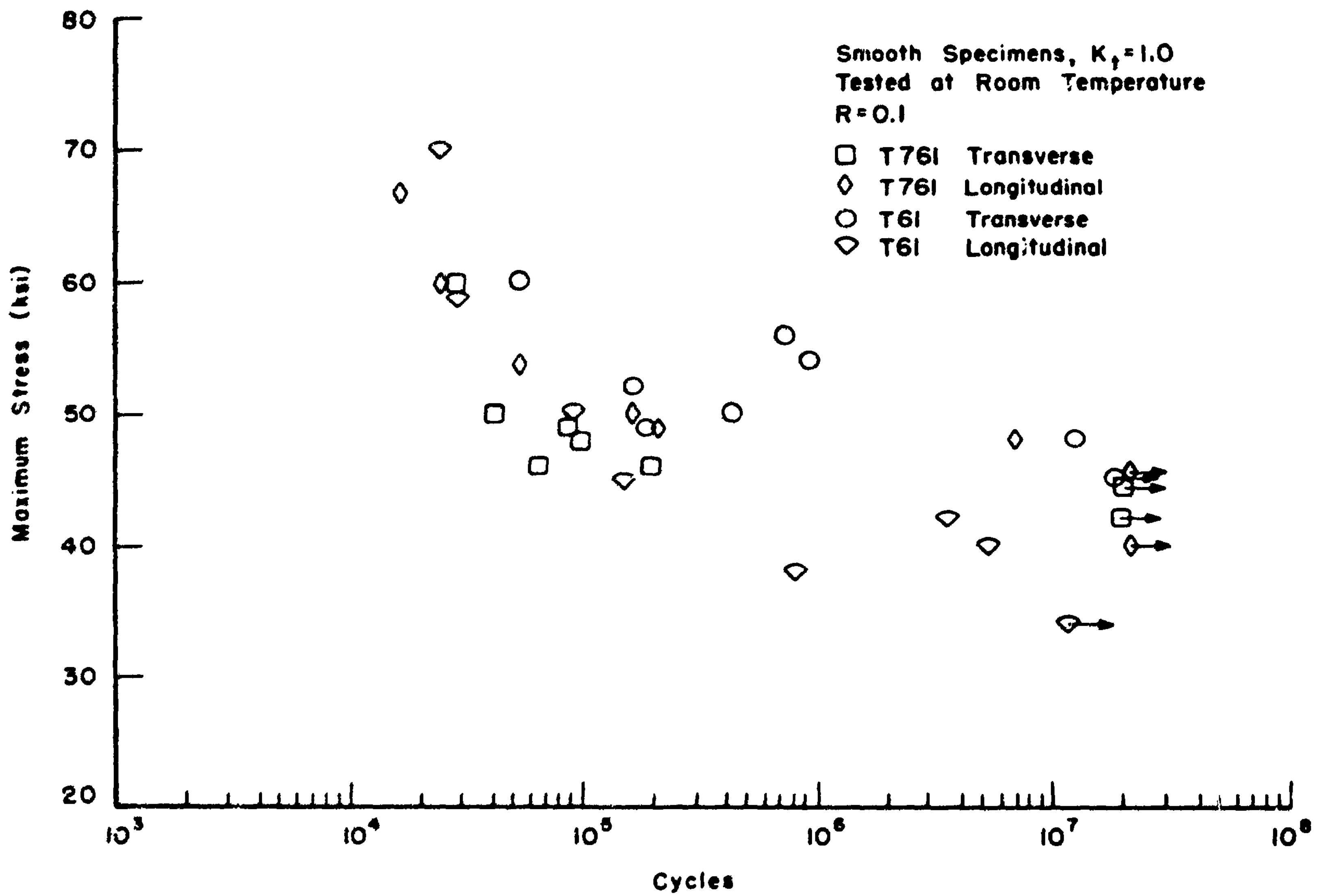

Figure 10. Smooth Fatigue Test Results for Aluminum Alloy 7475

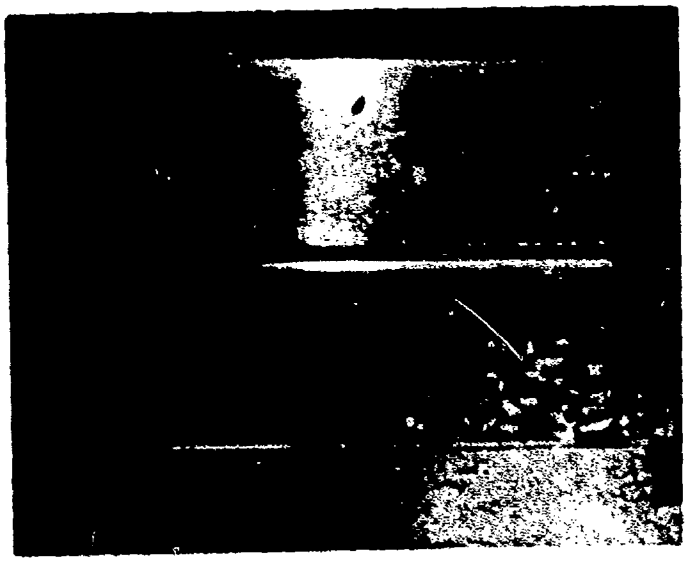

Figure 11. Exfoliation Samples Rolled Surfaces After 1200-Hour Exposure

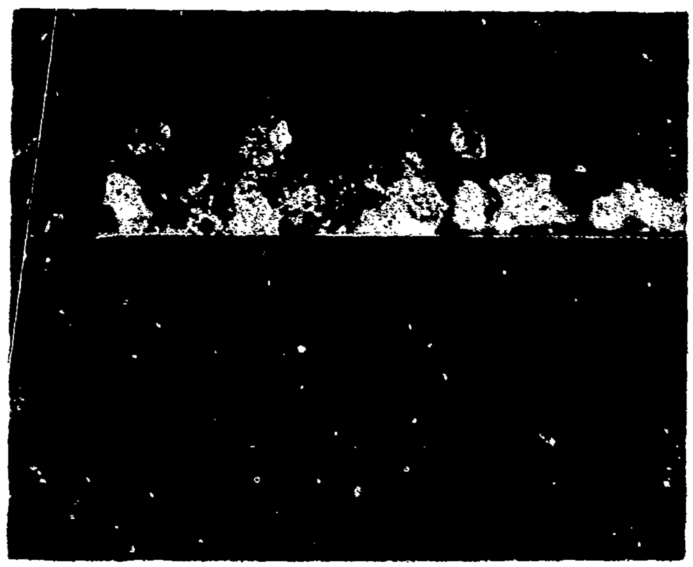

Figure 12. Beveled Edge of Exfoliation Samples After 1200-Hour Exposure

SECTION IV

CONCLUSIONS

1. The T61 heat treatment for aluminum alloy 7475 has superior tensile strength with no sacrifice in ductility when compared to the T761 heat treatment material.

2. The fatigue crack growth rate of aluminum alloy 7475 is comparable to other aluminum alloys.

3. There is no noticeable variation in crack growth rate between the two heat treatments or with a change in crack orientation.

4. The alloy 7475 is superior in fatigue to other currently-in-use aluminum alloys.

5. The test material showed good exfoliation resistance with the T761 heat treatment slightly superior to the T61.

SECTION V

REFERENCES

1. Alcoa Aerospace Technical Information Bulletin, Series 71, Number 6.

2. Alcoa Aerospace Technical Information Bulletin, Series 69, Number 4.

3. Tensile, Fracture Toughness, and Fatigue Properties of 2024-T851, University of Dayton Research Institute, UDRI-DR-71-05, June 1971.